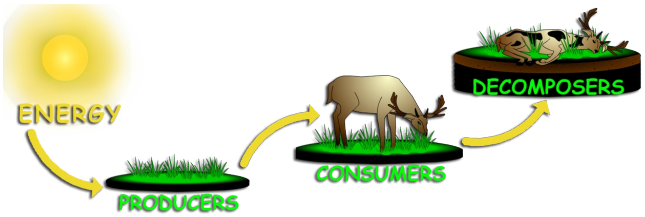

Lesson 3: Producers Make Their Own Food

Students explore the process of photosynthesis and draw conclusions about the important role producers play in the flow of energy.

Main Lesson Concept: Plants use the energy in light to make sugars out of carbon dioxide and water. Oxygen is released in this process.

Scientific Question: How do producers make food?

Objectives	Standards
• Students will use the inquiry process to design and carry out an experiment to determine what plants need to make food. • Students will describe what is needed to care for a rare plant. • Students will explain why producers are important to other living things.	**Partially meets**: 2061: 5E (6-8) #1 NSES: C (5-8) 4.2 NSES: C (5-8) 4.3 **Addresses**: 2061: 5E (6-8) #3 NSES: D (5-8) 1.11 NCTM: 4, 5, 9

Assessment	Abstract of Lesson
Write up of inquiry experiment and plant care description in Astro Journal.	Students use the inquiry process to determine what plants need to make food. Students observe that plants need sunlight, water, and air (carbon dioxide) to make food and that soil is needed for important minerals. They discuss the photosynthesis equation and complete a description of how they would care for a rare plant.

Prerequisite Concepts	Major Concepts
• Food provides molecules that serve as fuel and building material for all organisms. (Biology Lesson 2) • Plants release oxygen during the process of photosynthesis. (Atmosphere Lesson 5) • Oxygen is important to humans because it helps convert sugars into energy in the cells. (Atmosphere Lesson 5) • One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. (2061: 5A (6-8) #1)	• The flow of energy starts with the Sun. • Only plants and other producers have the ability to create food from the Sun's energy. • Plants use carbon dioxide, water, and sunlight to make sugars. This is called photosynthesis. • Oxygen is a by-product of photosynthesis.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore Part 1 sections
Days 2 to 10: Explore Part 2 (5 to 10 minutes a day)
Day 11: Explain and Extend Part 1 sections
Day 12: Extend Part 2 and Evaluate sections

Materials and Equipment:

- A class set of Astro Journal Lesson 3
- Chart paper
- Producer Experiment materials may include the following for each group:
- 2 healthy plants
- Water
- 2 pots with soil
- Reclosable plastic bags
- A sunlit place or grow lamp
- A dark area without sunlight
- 2 bean seeds
- Paper towels
- Marker
- 2 stakes or craft sticks
- Ruler
- Measuring cup
- Other materials will depend on the experimental designs students come up with (Make a list after Explore Part 1.)

Preparation:

- Gather materials for experiments.
- Duplicate a class set of Astro Journals.
- Prepare chart paper with major concept of the lesson to post at the end of the lesson.

Differentiation:

Accommodations

For students who may have special needs:

- Use a more guided inquiry process by providing them with a choice of experiments to carry out.
- Have them work in pairs, draw their observations, and explain their results and conclusions orally.

Advanced Extensions

Nitrogen is one of the important substances found in soil. Have students conduct research to determine why plants need nitrogen.

Engage (approximately 10 minutes)

1. **Draw on students' prior knowledge of the differences between plants and animals.**
   - Question: What are some differences between plants and animals?
   - *Answer: (Allow students to share their ideas. Student responses may include that plants can make their own food and animals cannot, that most plants are green and animals are a variety of colors, and that most plants are anchored in the soil and most animals move about freely.)*

   - Question: Do both animals and plants need energy to live? Explain your answer.
   - *Answer: Yes, both animals and plants need energy to grow and function.*

   - Question: Where do animals get their energy?
   - *Answer: Animals get their energy from eating food.*

   - Question: What do you think animals use energy from food for?
   - *Answer: (Allow students to share their ideas. Students may respond that animals use energy from food to grow, move, and function.)*

   - Question: Where do plants get their energy?
   - *Answer: Plants get their energy from sunlight.*

   - Question: What do you think plants use the energy from the sunlight for?
   - *Answer: (Allow students to share their ideas. Students may respond that plants use energy from the sunlight to grow.)*

2. **Bridge to this lesson.**
   - Say: Our goal for this unit is to determine Earth's biological conditions that help to support human survival. In the Biology Training module, you learned that producers are important for a habitable planet.

   - Question: What is a producer?
   - *Answer: (Allow students to share their ideas. If students are not familiar with this term, they may respond that a producer produces or makes something.)*

   - Say: Producers make something. Producers are living things that can make their own food.

   - Question: What is an example of a living thing that can make its own food?
   - *Answer: Plants are living things that can make their own food.*

   - Question: Do you think that plants are the only living things on Earth that can make their own food? Explain your answer.
   - *Answer: (Allow students to share their ideas. Students may respond that there are other living things that can make their own food. Students may have seen algae growing on the top of a lake.)*

   - Say: Algae and some types of bacteria can also make their own food. Our focus today will be on plants because these are the producers that we are most familiar with.

   - Question: Why are plants important to have on a planet?
   - *Answer: Plants are important because they provide food for animals.*

- Question: In the Atmosphere unit, what did you learn are some other reasons that plants are important to have on a planet?
- *Answer: Plants take in carbon dioxide and release oxygen.*

- Question: Why is carbon dioxide important to have on a planet?
- *Answer: (Accept all correct answers. Students may respond that carbon dioxide is a greenhouse gas that helps regulate Earth's moderate surface temperature.)*

- Question: Why is oxygen important to have on a planet?
- *Answer: (Accept all correct answers. Students may respond that oxygen is important because animals use oxygen to help convert sugars into energy in the cells. Students may also recall that oxygen is highly reactive and as a result plays an important role in many chemical reactions such as photosynthesis, combustion, and converting sugars into energy.)*

- Say: We know that plants release oxygen into the atmosphere.

- Question: Do you think plants take anything from the atmosphere to make food?
- *Answer: (Allow students to discuss and share their ideas about this.)*

- Say: In our lesson today, we will find out what plants and all other producers use to make food.

3. Introduce the Scientific Question.

- Say: The Scientific Question we will explore today is:
  -How do producers make food?

Explore PART 1 - (approximately 35 minutes)

1. Have students hypothesize what plants need to make food to begin the Producer Experiment.

- Question: What do you think plants need to make food?

- Have students record their predictions in the Hypothesis/Prediction section of their Astro Journals.

2. Discuss developing an experiment with students.

- Question: How could we test your hypothesis?
- *Answer: (Accept all reasonable answers. Students may respond that we can develop an experiment to test the hypothesis.)*

- Question: In your hypothesis, how many of you listed more than one item that plants need to make food?
- *Answer: (Most students will respond that they listed more than one item that plants need to make food.)*

- Question: If plants need more than one item to survive, how can we test for the need for a single substance?
- *Answer: (Allow students to share their ideas.)*

- Question: What would happen if we denied the plants all of the things we think they need except for one?
- *Answer: The plants would die.*

- Question: Why would the plants die, if they need that substance?
- *Answer: The plants would die because they need the other substances too.*

- Question: How can we set up our experiment to determine if our plants needs an item without killing the plant?
- *Answer: (Allow students to share their ideas.)*

- Say: Because plants need more than one item to live, you should set up an experiment using two plants. One plant will receive everything that it needs, while the second plant will receive all of the items it needs except for the one you are testing.

- Question: Why should you not test more than one item in your experiment?
- *Answer: If you test more than one item in your experiment, then you will not know what caused the change in your experiment.*
  Note to Teacher: With older students, the terms "control" and "variable" could be introduced at this point in the discussion. You may also want to point out that setting up the plan for how the experiment will be conducted is referred to as an "experimental design." Also, be sure to discuss with students the importance of having everything exactly the same in both the control and variable, except for the item that is being tested.

- Question: How will we know if the item you are testing was needed by the plant to make food?
- *Answer: (Allow students to share their ideas. Many students will respond that if the plant denied the item doesn't grow while the one given the item grows, then the plant needed the material to make food.)*

3. Put students into groups and ask them to discuss what item they would like to test to determine if plants need this to make food.

Note to Teacher: Plants need water, carbon dioxide, and sunlight to make food, but in order to stay healthy and survive, they also need minerals and other substances found in the soil. These substances assist the plant in creating special cells and chemicals that aid in photosynthesis. Many students think that plants need soil to make food. They don't, as long as they are provided the necessary substances to stay healthy. (This is what the science of hydroponics is based on). Encourage groups to develop an experiment to determine if plants need one of these items: water, gases (carbon dioxide), sunlight, or soil. Listed below are sample experiments. They can also serve as teacher demonstrations if a group of students does not complete one of the experiments.

Water Experiment: Use two plants. Water one plant every day or every other day with the same amount of water. Be careful not to over-water the plant, as this can also adversely affect its ability to survive. The second plant will have all of the same conditions as the first—gases, sunlight, and soil, but it will not receive any water.

Carbon Dioxide Experiment: At this point in the lesson, students may not know that plants need carbon dioxide to make food. If no group develops an experiment around whether plants need gases, then conduct a teacher experiment/demonstration at the same time that students are conducting their experiments. A simple experiment to determine if plants need carbon dioxide to make food is to use two plants. Place one plant in a reclosable plastic bag and seal the bag. Make a hole the size of a half dollar in a second reclosable plastic bag. This hole will allow carbon dioxide to enter the bag. Place a second plant into the reclosable plastic bag with the hole and seal the bag.

Sunlight Experiment: Use two plants. Place one plant under a grow lamp or in an area that gets sunlight. Place the second plant in a dark area such as a closet. Both plants should receive the same amounts of water and carbon dioxide.

Soil Experiment: In this experiment, one plant will be planted in soil, and the other plant will not. Both plants should receive the same amounts of sunlight, water, and carbon dioxide. To really see that soil is not necessary to make food, you might want to use plants that grow well out of soil, such as water plants available at the local nursery or lima bean plants. Students conducting this experiment should start with two healthy plants, to ensure that the cells and chemicals necessary for photosynthesis are already developed.

MISCONCEPTION: Students think that plants get their food from the environment rather than manufacturing it internally. Students have difficulty in identifying sources of energy for plants and animals. Students believe that plants get their food from soil. Plants do get minerals and nitrogen-based substances from the soil that provide some of the building materials and are used in the process of photosynthesis. However, a large percentage of the building material that makes up plants comes from carbon in carbon dioxide from the air, and plants get energy from the food they manufacture internally. Observation and discussion of the experiments developed in this section will help students better understand these concepts.

- Once each group has decided what they will test in their experiment, have them develop a question for their experiment.
  Note to Teacher: For younger students, you could help students with their question by writing on the board, "Does a plant need _____ to make food?" Students would fill in the item that they are going to test.

- Have students record their question in the Scientific Question section of their Astro Journals.

4. Have students work in their groups to develop a hypothesis to their question.

- Go over expectations for hypotheses from the inquiry rubric and model how to revise a hypothesis to improve it (i.e., make it clearer, testable, more specific, etc.)

- Have students record their hypothesis in their Astro Journals.

5. Model for students how to create a "test" for the hypothesis and demonstrate how the Materials, Procedures, and Data Collection for the test will be recorded in the Astro Journal for this lesson.

Note to Teacher: Make sure that the students are thinking in terms of data—what data they will be collecting, how they will be measuring their data, and how that is either going to confirm or refute their hypotheses.

6. Give students some time to put together their Materials and Procedures list in their Astro Journal in order to figure out what data they will be collecting and how they will measure their data.

Note to Teacher: Depending on the time available, fast growing plants or fast growing seeds such as bean seeds can be used for the students' experiments. If students start their experiment from seeds, we recommend that you germinate the seeds first in order to make sure they are viable seeds. To germinate seeds, simply wet a piece of paper towel, place the seeds on the paper towel, and fold the paper towel in halves a few times until it is small enough to fit in a sandwich bag. Seal the sandwich bag to keep the moisture in and check on the seeds every day or every other day until they have begun to sprout.

7. **Have students share their questions, hypotheses, and experiment plans.**
   - Ask questions to help groups clarify their plan, but try to avoid giving them the answers.
     Sample questions:
     - How does this experiment test your hypothesis?
     - What specific data are you collecting?
     - How will you know if the item you are testing affected the plant?
     - How will you be sure that some other item didn't affect the plant?
     - What two samples will you compare? How will they be alike? How will they be different?
     - How will your data confirm or refute your hypothesis?
     - How are you going to measure your data?

     Note to Teacher: Corrections should be focused on science process, not the accuracy of the hypothesis. An incorrect hypothesis with a solid experimental plan is fine. A correct hypothesis without a solid experimental plan should be revised.

8. **Ask students for a list of materials they will need to conduct their experiments.**

Explore — Part 2 - (approximately 5-10 minutes daily for 1 - 2 weeks)

1. **Have students review their hypotheses and experiment plans and then set up their experiments.**

2. **Students should perform their experiments and collect data daily. This experiment should be conducted until the plants begin to show reactions to their environments.**
   - Have students record their data in the Data Collection section of their Astro Journals.

   - Encourage students to record more data than just height of the plant. Students can also record observations about the overall health of the plant and the color of the leaves.

     Note to Teacher: Students need a consistent place to measure from. One idea is for students mark a line on the inside of the pot with a permanent marker. A second idea is to use a stake such as a craft stick in the soil marked with a line. Students often measure from the soil, and the soil is not consistent since it will be lower after being watered than when it is dry.

Explain (approximately 25 minutes)

1. **Instruct students to organize their data into a chart or graph in the Charts/Graphs section of their Astro Journal.**
   Note to Teacher: You may want to do a formal introduction or review of graphing. Most likely some kind of line graph indicating growth of plant over time will be the best way to present the information.
   - Students may need some assistance in choosing the most appropriate way to graph their data.
   - Sample Questions:
   - How does this graph either support or refute your hypothesis?
   - Is there any other kind of graph that might better show what your data demonstrate about your hypothesis?
   - What kind of change are you looking for in your plant that would help to answer your hypothesis? How can you graph this change?

2. **Have students fill out the Results and Conclusions sections in their Astro Journals.**

3. **Ask some groups to share their hypotheses, data, and what they think their data demonstrate about their hypotheses. Discuss what the class can learn from each individual experiment and the experiments as a whole.**

MISCONCEPTION: Many students may feel that if their hypothesis is not "right" then their experiment is a failure. Emphasize that this is not true. Scientific understanding grows when we eliminate incorrect answers to scientific questions. The success or failure of a hypothesis and experiment is based on the accuracy of the process, not the result. Either way, we learn something.

4. **Discuss student conclusions from their experiment.**
   - Question: What conclusions did you make from your experiment?
   - *Answer: (Accept all reasonable answers. Students may respond that the plants need water, gases [carbon dioxide], and sunlight to grow.)*

   - Question: Which plants survived in the experiments? Why do you think these plants survived?
   - *Answer: Responses will vary depending on the experiment. Student responses hopefully will include that the plants that survived had the materials necessary for plants to make food. These materials are sunlight, water, and gases (carbon dioxide).*

   - Question: Why didn't the other plants survive?
   - *Answer: The other plants did not survive because they did not have the materials necessary for plants to make food.*

   - Question: From completing these experiments, what have you learned about how plants make food?
   - *Answer: Plants need sunlight, water, and carbon dioxide to make their food.*

   - Question: What happened to the plants that were grown in and out of soil?
   - *Answers may include: Both plants grew, but the plant in the soil seemed healthier.*

   - Question: So do plants need soil to make food?
   - *Answers may include: Plants do not need soil to make food; however, without soil they would not be very healthy and might die.*

- Question: If the plants didn't need soil to make food, what does soil provide for plants?
- *Answer: Soil stores minerals and nitrogen-based substances that plants need, holds roots, and provides support for plants.*

- Question: Do you think that humans could survive if they only ate foods such as cookies, candy bars, and chips?
- *Answer: (Allow students to share their ideas. Students will most likely respond that humans could survive if they only ate foods such as cookies, candy bars, and chips.)*

- Question: If you only ate these foods, do you think you would be healthy?
- *Answer: If you only ate these foods, you would not be healthy.*

- Say: These foods don't have much protein, so you would survive for a while, but eventually your body would start to break down muscle to get protein, which would result in organ damage and disease.

- Question: How can you compare this to a plant's use of soil?
- *Answer: (Accept all reasonable answers. Students may understand that plants use soil for minerals to stay healthy and for some of their building materials.)*

- Say: Just like we could get our energy from just eating junk food, a plant could get its energy from just water, sunlight, and carbon dioxide. To be healthy, we need to eat things with vitamins and minerals too, just like plants need soil for their minerals to help build some of their plant parts. For example, we learned in the Atmosphere unit that nitrogen is an important mineral. Plants get nitrogen from the soil. Nitrogen makes up a part of all living cells, is part of all proteins and is part of chlorophyll, which is what plants use to make food from sunlight. So, plants do not need soil to make their food, but most would not be very healthy without it.

  Note to Teacher: Examples of other minerals that plants need include potassium, which is used to build protein and is used in photosynthesis, and calcium, which is an important material that makes up plant cell wall structures.

Extend/Apply Part 1 - (approximately 20 minutes)

1. Connect information from this lesson with photosynthesis information from Atmosphere Lesson 5.

- Say: In Atmosphere Lesson 5, we learned the chemistry of photosynthesis. Today we are going to review the photosynthesis equation.

- Question: What do plants need to make food?
- *Answer: Plants need water, carbon dioxide, and sunlight.*
  Note to Teacher: Write "water + carbon dioxide + sunlight" on the board.

- Question: What do plants make during photosynthesis?
- *Answer: Plants make food and oxygen.*

- Question: What is the food made of?
- *Answer: The food is made of sugars.*
  Note to Teacher: Draw an arrow after sunlight, and write "sugars" on the board.

- Question: Plants produce oxygen through photosynthesis. What happens to this oxygen?
- *Answer: Plants release it into the atmosphere.*

Note to Teacher: Write "+ oxygen" on the board. You should now have the entire photosynthesis equation written on the board in words: water + carbon dioxide + sunlight → sugars + oxygen

- Say: Oxygen is called a by-product of photosynthesis, because plants produce it and release it into the air.

MISCONCEPTION: A commonly held misconception is that plants don't use oxygen. However, plants use oxygen just like we do. They need oxygen to release the energy in the sugars they've created. They use the energy to function and grow (usually at night). When plants need oxygen, they take it in from the atmosphere just like us. So, plants both take in and release oxygen.

- Question: Look at the equation on the board written in words. From atmosphere, what did we learn were the chemical symbols for these substances?
- *Answer: (Accept all correct answers.)*

Note to Teacher: After students have shared the chemical symbols they know, complete the equation with any symbols that they did not know, as well as the numbers in front of the compounds. The photosynthesis equation using chemical symbols is:

$6H_2O + 6CO_2 + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$

2. Discuss the role photosynthesis plays in producing energy.

- Question: In Biology Lesson 2, what did we learn about sugar?
- *Answer: We learned that sugar provides us energy.*

- Question: Look at the equation on the board. Where do you see energy in the equation?
- *Answer: Students should respond that they see energy as sunlight and as sugar.*

- Question: What are plants doing in this equation?
- *Answer: (Accept all reasonable answers. Students may respond that plants are taking sunlight, water, and carbon dioxide and converting it to sugar.)*

- Say: In this equation, plants are making the materials into a new form of energy—sugar.

3. Discuss the importance of producers to other living things.

- Question: Can humans convert sunlight, water, and carbon dioxide into sugar?
- *Answer: No, humans cannot.*

- Say: Producers are the only living things that can do this.

- Question: We saw that there is energy as sunlight and as sugar in the photosynthesis equation. Why don't plants just use sunlight for their energy?
- *Answer: (Allow students to share their ideas. Students may respond that the energy needed for a plant to grow and be healthy needs to be packaged in a special way so that the plant can use it.)*

- Question: What do most of your electronic devices run on at home? Do any of them use solar energy?
- *Answer: Student responses will vary. Most likely students will respond that their electronic devices at home run on batteries or electricity. Some students may have an electronic device that uses solar energy, like a calculator. When devices do run on solar energy the energy is used right away or is stored in a battery for later use.*

- Say: Living things need energy to be in a form that they can use just like electronic devices.

Extend/Apply Part 2 - (approximately 30 minutes)

1. **Have students apply their knowledge of photosynthesis in the Plant Care Activity.**
   - Say: You are now experts on what plants need in order to make food and survive. Pretend that you are a world-renowned scientist specializing in the care of plants. A one-of-a-kind plant is brought to your lab, and you are asked to care for it. Before the plant can be left in your care, you must prove that you have the knowledge to correctly care for this plant. You need to explain how you will care for the plant and why scientifically your care will keep the plant healthy.

   - Have students write their essays in their Astro Journal.

Evaluate (approximately 15 minutes)

1. **Have students share their Plant Care Activity essays. Make sure that they understand that plants need sunlight, water, and carbon dioxide to make food, and that they need soil for minerals and other important substances.**

2. **Discuss students' responses in their Astro Journals to ensure they have mastered the major concepts.**
   - Question: What do plants produce through the process of photosynthesis?
   - *Answer: Plants produce sugars and oxygen.*

   - Question: What do plants use to make sugars?
   - *Answer: Plants use water, carbon dioxide, and sunlight to make sugars.*

   - Question: Why are producers important for human survival on Earth?
   - *Answer: Producers are important for human survival on Earth because they provide oxygen and food. Producers are the only living things that can make food from sunlight.*

3. **Collect students' Astro Journals and evaluate them to ensure that they have mastered the major concepts:**
   - The flow of energy starts with the Sun.
   - Only plants and other producers have the ability to create food from the Sun's energy.
   - Plants use carbon dioxide, water, and sunlight to make sugars. This is called photosynthesis.
   - Oxygen is a by-product of photosynthesis.

4. **Bridge to next lesson.**
   - Say: Today, we learned how plants make food through the process of photosynthesis. In the next lesson, we will learn how consumers get energy from other living things.

   Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Astro Journal Biology Lesson 3:
Producers Make Their Own Food - Producer Experiment

Class/Period:

Name:

Date:

Scientific Question:

How do producers make food?

Hypothesis/Prediction: What do you think plants need to make food? Why do you think this?

Producer Experiment Question:

Does a plant need _____ to make food?

Producer Experiment Hypothesis/Prediction: Do you think a plant needs the item in your question to make food? Why do you think this?

Materials: What materials will you use to test your hypothesis/ prediction?

Procedure: What steps will you take to carry out your experiment?

Astro Journal Biology Lesson 3:
Producers Make Their Own Food - Producer Experiment

Name:

Class/Period:

Date:

Data Collection: Record and display your data in a chart, table, or graph.

Charts/Graphs:

Results: What do plants need to make food? Use data from your experiment to support your answer.

Conclusions: Compare and contrast your hypothesis and results. How did testing your hypothesis/prediction and drawing relationships change your original ideas?

Astro Journal Biology Lesson 3:
Producers Make Their Own Food

Name:

Class/Period:

Date:

Plant Care Activity

You are now experts on what plants need in order to make food and survive. Pretend that you are a world-renowned scientist specializing in the care of plants. A one-of-a-kind plant is brought to your lab, and you are asked to care for it. Before the plant can be left in your care, you must prove that you have the knowledge to correctly care for this plant. You need to explain how you will care for the plant and why scientifically your care will keep the plant healthy. In this description, be sure to explain how plants make food and how plants contribute to human survival.

Your essay must include:

- A diagram of the plant with labels of what you will provide.
- A description of why it is necessary to provide each these items based on the photosynthesis process. (How do plants make food?)
- A description of how your plant will obtain the minerals and other substances it needs to be healthy.
- The importance of producers for human survival.

Your essay will be evaluated using the following rubric:

4	- Essay clearly and accurately explains how to care for a plant. - Essay has all required parts and uses reasoning to create an exceptionally powerful and detailed explanation.
3	- Essay clearly and accurately explains how to care for a plant. - Essay has all required parts and uses good reasoning in explanations.
2	- Essay is not completely clear or accurate in explaining how to care for a plant. - Essay has most required parts and uses some good reasoning in explanations.
1	- Essay is not clear or accurate in explaining how to care for plants, is missing several parts, and uses little or no good reasoning.